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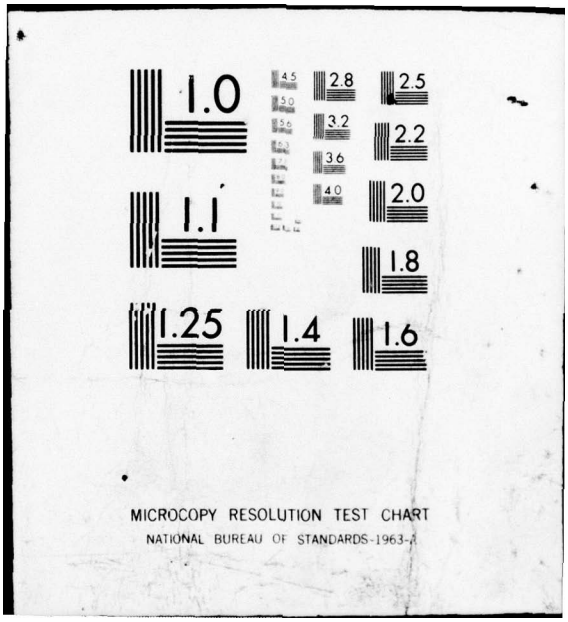
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THE HARWELL PROTON LINEAR ACCELERATOR

The British Government has approved the construction of a proton linear accelerator of 600 Mev for the Atomic Energy Research Establishment, Harwell. The money for the first year's program is in hand, the contracts with industry are being made, and preliminary test holes for the foundations are being bored. The present cost estimate is £1,750,000 ($4,900,000 U.S.) but actual approval of expenditure of funds will be on a year to year basis, with the thought that in an emergency construction can be stopped half way (say) and the part that has been completed will still be usable.

The general design of the accelerator is the responsibility of the General Physics Division, Harwell, but the detailed design and construction will be done by Metropolitan Vickers, Limited, who will build all parts of the accelerator with the exception of the high power radio-frequency tubes. The estimated time of completion is not less than five years.

It is hoped to achieve a time average proton beam of some microamperes at 600 Mev. Since this beam is automatically available externally (in contrast to the FM cyclotron) it is believed that this will be a unique facility in the production of meson beams and in the availability of sufficient intensity for really precise experimental measurements in the field of high energy nuclear physics.

The injector will be a 500 kev Cockcroft-Walton set made by Philips and employing selenium rectifiers. The first section of the linear accelerator will take the protons to an energy of 10 Mev and will operate at a frequency of 200 megacycles. Radial focusing will be obtained by the use of grids. Next there will be two 40 ft accelerator tanks giving energy increases of 20 Mev each. At 50 Mev there will be a gap of 1 or 2 meters length and the operating frequency will change from 200 megacycles to 400 megacycles. This frequency is continued for the rest of the accelerator. It is also planned to have the possibility of bending the proton beam out of the accelerator at 50 Mev and also at 150 Mev and 350 Mev. The total length of the accelerator will be about 270 meters for the full energy of 600 Mev.

Considerable theoretical work has been done by the Harwell group on beam dynamics including the effects of grid focusing, strong focusing and the effect of gaps in the accelerator. It is planned to use magnetic strong focusing for energies above 10 Mev.

One of the reasons for going into the linear accelerator program is to strengthen the position of Britain in the field of high power vacuum tubes usable in the frequency range of 200 and 400 megacycles, and the development of tubes of this type is an essential part of the program. The total pulse power requirements for the accelerator will be approximately 150 megawatts with a duty cycle of about 1 per cent. The repetition rate is planned at 50 pulses per second. A large triode has been constructed and will be tested at Harwell with the final design figures of 5 megawatts at 400 megacycles kept in mind. One basic feature of the tube is a cylindrical anode somewhat less than a half wavelength in both length and circumference which is excited by the electron stream so that a voltage node exists at both ends. Water and high voltage at 40 kv are brought in through seals on four vertical bars that support the anode. The filaments are located on the outside so as to provide maximum emitting area. They are vertical strips approximately 6" long by 1/4" wide located between vertical grid bars approximately 1/4" on a side. Shaping of the cathode and grid geometry, to produce an effective Pierce cathode, provides focusing of the electron stream and consequent low grid current. The anode at the center has a small area for heat dissipation but this is no disadvantage for pulse operation. Commercial production of sealed-off tubes of this type will be undertaken by the English Electric Company.

A second line of attack on the rf problem is the development of high power klystrons at Imperial College, London. These will be 5 ft high, will require a plate voltage of 100 - 200 kv and will deliver a peak power of between 1 and 2 megawatts.

SEMICONDUCTING TITANIUM NITRIDE

An interesting semiconducting modification of titanium nitride layers was recently discovered in the laboratories of Dr. A.Münster (Metallgesellschaft, Frankfurt). It was found that thick titanium nitride layers deposited on silica glass exhibit a temperature dependence of conductivity characteristic of semiconductors. The layers which were up to 0.01 mm thick are otherwise indistinguishable from the usual titanium nitride layers which are metallic conductors and have been extensively studied by Münster in the past years. It appears that the silica glass substrate plays a key role in the formation of such a semiconductor and one might speculate that oxygen in the form of atomic or molecular ions perhaps enters the nitride lattice. The metallic and semiconducting nitride layers yield identical X-ray structure patterns.

Another recent observation of this laboratory in the field of titanium nitride which may be of possible interest concerns the properties of cathode materials. Titanium nitride was found unsuitable for such applications some years ago because it dissociates at a cathode temperature of 2000°C. It was recently observed by Dr. Münster that solid solutions of titanium carbide and titanium nitride exhibit greatly improved properties. The saturation potential is only 20 volts and they can apparently withstand very much higher temperatures than pure titanium nitride.

THE RAMAN SPECTRA OF MOLTEN SALTS

Dr. W. Bues (Stuttgart) has completed a valuable study on the Raman spectra of a series of molten nitrates and lithium perchlorate, using the relatively simple technique previously mentioned (cf. ESN 7, 159 (1953)). The spectra of molten nitrates of lithium, sodium, potassium and silver, indicate that the strong fundamental vibrational frequency of the nitrate group around 1050 cm^{-1} is markedly dependent on the cation. It moves from 1061 to 1030 cm^{-1} in

the above mentioned series. In the case of silver nitrate a number of weak new lines are also observed which have not yet been definitely assigned. It appears probable that both in silver nitrate and in lithium perchlorate undissociated molecules are also present in the melt.

In a 50 - 50 mixture of silver nitrate and lithium nitrate the strong fundamental is halfway, at 1048 cm^{-1}, between its location for the pure salts. This is also its value in aqueous lithium nitrate solutions.

THE CHEMISTRY OF HIGH TEMPERATURES

A national meeting on the chemistry of high temperatures was held in Paris on 11 - 13 May 1954 under the sponsorship of the Commission of High Temperature Chemistry of the Centre Nationale de la Recherche Scientifique. The discussion was divided into five sessions dealing respectively with techniques of heating to high temperatures, new materials of high temperature applications, physical studies at high temperatures, electrolysis and electrolytic phenomena at high temperatures, and measurements of high temperatures. Most of the material presented was of a review nature and will be only very briefly mentioned below; more details can be found in Technical Report ONRL-46-54. The complete proceedings, including the discussion, will be available from the organizers.

The Electronic Torch

The electronic torch, or discharge torch, is a high pressure electric discharge produced in certain gases under the influence of high frequencies. The discharge is attached to a single electrode and presents an appearance similar to a flame. A recent study of this phenomenon at frequencies of 10^9 cps using air, N_2, CO_2 and A was that of J. D. Cobine and D. A. Wilbur (J. Appl. Phys. 22, 835 (1951)). At this meeting J. Laroche described his work carried out with M. Magat (Paris) in which a wide variety of gases were studied in such a torch, operating at 1.3×10^9 cps. The design of the apparatus was similar to that of Cobine and Wilbur.

The torch functions in a stable manner in nitrogen, oxygen, chlorine, argon, carbon dioxide and sulfur dioxide, but cannot function at all in hydrogen or hydrogen-containing gases such as ammonia, methane, etc. Mixtures of gases belonging to these two groups are satisfactory media provided

the concentration of the "inactive" gas is not too great. The shape, structure and colors of the flames in these different gases show characteristic variations.

Spectroscopic studies, together with the other measurements, lead to the conclusion that the heat evolution observed is due both to recombination of atoms and to deionization of the various ions present.

M. Laroche investigated the formation of NO from its elements in such a torch. The maximum yield of NO was obtained with an equimolar mixture of nitrogen and oxygen, at a flow rate of 40 l/h and was 6 per cent NO, while the yield at the same flow rate in air itself is 4.8 per cent NO. The best efficiency was found to occur at a much higher flow rate of 400 l/h of air, and amounts to 53 grams of nitric acid per kwh. Under these conditions only 1.2 per cent NO is formed.

Alloys of Carbides

The structure and properties of pseudo-binary and pseudo-ternary alloys formed by the carbides of tungsten, zirconium and titanium were discussed by T. Tombrel. The temperature dependence of the solubility of tungsten carbide in zirconium carbide and in a 3:1 solid solution of titanium carbide and zirconium carbide was obtained between 1700° and 2600° C. X-ray methods and micrographic techniques were employed. It was found that the solubility in the first case increases from 26 mole per cent at 1700°C to 58 mole per cent at 2550°C. In the second system the solubility is considerably greater but its temperature dependence is less: it varies from 42 mole per cent at 1700°C to 63 mole per cent at 2320°C.

Cermets

The interesting, relatively new field of mixtures of oxides and metals was discussed by S. Tacvorian. The system which he discussed in some detail is chromal, the sintered mixtures of chromium and alumina. The three important variables which influence the properties of the chromals are the chromium content, the composition of the metallic phase, and the particle size of the powders. The chromium content was described in terms of three ranges of composition: (1) mixtures containing up to 30 per cent Cr by weight are characterized by low electrical and thermal conductivity and poor resistance to thermal shock; (2) be-

tween 30 per cent and 50 per cent Cr the electrical conductivity is considerably increased and there is negligible weight gain by oxidation in 300 hours at 1000°C; creep resistance is also extremely high; (3) in the range from 50 per cent to 80 per cent Cr the thermal shock resistance is excellent while the creep and oxidation resistance is still quite satisfactory.

A cermet in which 18 per cent of the Cr is replaced by Fe is less expensive, has good oxidation resistance but poorer thermal shock characteristics. An aggregate of only iron with alumina is unsatisfactory but additions of tungsten to chromium have resulted in some excellent materials. As regards the particle size, results obtained with Cr powder of 5, 20 and 45 μ show that the finest powder gives the best results.

MOLECULAR COMPOUNDS INVOLVING HYDROXYL IONS

Detailed investigation of the absorption spectra of s-trinitrobenzene and other aromatic nitrocompounds in alkaline media recently led A. Bier and Prof. J.A.A. Ketelaar (Amsterdam) to postulate the occurrence of complexes involving the aromatic nitrocompounds and hydroxyl ions.

The most extensive measurements were made on s-trinitrobenzene in KOH solution of 0 - 1ON, in the concentration range 0.2-1.0 x 10^{-4}M. Other basic media used were sodium bisulfate solutions, 33 per cent trimethylamine, diethylamine, hydrazine hydrate and pyridine. The spectrophotometric observations in KOH solutions indicate two molecular compounds between the aromatic and OH ions, in 1:1 and 1:2 ratios. The former has absorption maxima at 276 m μ, 438 m μ, 460-480 m μ (uncertain), and at 510 m μ. The 1:2 complex has no absorption bands in the visible region. Studies in the other alkaline media confirm these bands in all cases where hydroxyl ions are available.

A number of other aromatic nitrocompounds were shown to behave in an analogous manner.

The well known reversible color change of s-trinitrobenzene, and of other nitrocompounds, occurring when their aqueous solution is made strongly alkaline is thus not due to proton transfer. This conclusion was strengthened by the recently published negative results of exchange experiments in heavy water (cf. Ketelaar et.al., Rec., 73, 38 (1954)).

ULTRASONICALLY INDUCED LUMINESCENCE

Recent experiments in the laboratories of Prof. P. Günther (Karlsruhe) indicate that the well known luminescence observed when liquids containing dissolved gases are exposed to strong ultrasonic radiation may be due to high electrostatic fields developing within the liquid and particularly at its surface and its interface with the container. Extensive investigations have been made on aqueous solutions containing various rare gases and oxygen insonified at a frequency of 175 kc. Solutions containing xenon show a particularly strong luminescence which can be easily seen with the unaided eye. It was found that when a 50 cycle modulation frequency is imposed on the ultrasonic field there is no effect on the emitted light, i.e. it does not show any 50 cycle periodicity. Prof. Günther believes that this observation disproves the previous suggestion that these luminescence phenomena are due to the adiabatic compression and expansion of cavitation bubbles in the liquid.

The spectrum of the strong xenon luminescence indicates that it is excited to a level corresponding to 8 ev and thus the well known occurrence of various chemical reactions under the influence of ultrasonic radiation is readily understood. The xenon band observed is broadened in a manner similar to that observed by Stranski for the oxygen band in his extensive studies on triboluminescence.

The investigations are continuing using strong salt solutions to reduce the vapor pressure of water in any cavities found in these systems. This will permit the study of the quenching effect of water vapor on sonoluminescence.

OXIDATIVE PHOSPHORYLATION BY ISOLATED SPLEEN MITOCHONDRIA

Adult male rats weighing 300 - 400 gm were used by Doctors D. W. van Bekkum and H. Th. M. Nieuwerkerk of the Medical Biological Laboratory of the National Defense Research Council (T.N.O.), The Netherlands, to study the effects of total body x-radiation on oxidative phosphorylations by isolated spleen mitochondria. This work was begun several years ago but refinements in technique are still being developed. In an attempt to assess the effect of x-radiation on the cytoplasm of cells the oxidative phosphorylation process, which is considered as being of prime importance in maintaining the energy supply for many endergonic processes in cells, was selected as a prototype system for investigation. Rats were killed at intervals after irradiation, the spleens removed and homogenized, and the mitochondria isolated by differential centrifugation in sucrose solution. Controls were processed simultaneously

in each experiment. The effect of total body x-radiation (1100 r) has been studied at 2, 4 and 24 hours after irradiation. At 2 hours after irradiation oxidative phosphorylation was found to be hardly, if at all, affected, but 4 hours after irradiation phosphate uptake was decreased to 50 per cent of the control value. Oxygen uptake was also impaired although to a lesser extent. Twenty-four hours after irradiation these effects were still present. The decrease in phosphate and oxygen uptake (and decrease in the P/O ratio) is believed to be the result of some impairment of mitochondrial metabolism. The effect described was observed when the substrate used was either succinate or alpha-ketoglutarate.

Further investigations of the metabolism of isolated spleen mitochondria have been made. It has been found that successive washings of the mitochondria during the process of isolation decrease the phosphorylating capacity of the preparations, but this can be restored by the addition of diphosphopyridine nucleotide (DPN). This phenomenon is more readily observed with alpha-ketoglutarate as a substrate than with succinate. There is an increased adenosine triphosphatase activity of spleen homogenates after irradiation of the animals. This is preceded by the disturbance of oxidative phosphorylation and is probably an independent reaction not related to the disturbance of oxygen and phosphate uptake. X-ray doses as low as 300 r are sufficient to produce decreased phosphorylation by the isolated spleen mitochondria studied 4 hours after irradiation of the animal. Finally, it has been determined that the prophylactic administration of beta-mercapto-ethylamine (Becaptan) does not influence the disturbance in the oxidative phosphorylation process.

NEW JOURNALS

Reorganization of Zeitschrift für Physikalische Chemie

The Zeitschrift für Physikalische Chemie has been split into two journals with the same name. One of these continues in Leipzig (East Germany) and carries on the old volume numbering; the other is published in Frankfurt am Main, with Neue Folge (New Series) added to the title and the first issue has recently appeared. Its editorial board includes Professors Bonhoeffer, Jost, Förster and Schwab, and it may be expected to become the more important one of the two.

Analytical Abstracts

The first four issues of the new, monthly abstract journal, "Analytical Abstracts", have appeared since 1 January 1954. Its appearance is undoubtedly at least partly due to the recent discontinuation of British Abstracts. This journal is published monthly by the Society for Analytical Chemistry (London) and deals with all branches of analytical chemistry. It includes sections on general analytical chemistry, inorganic analysis, organic analysis, biochemistry, and general technique and laboratory apparatus. In addition a recent issue contained a listing of Russian scientific papers of interest to analytical chemists, of which English translations are available.

"Analytical Abstracts" is published by W. Heffer and Sons in Cambridge at a subscription rate of £2.10.0. per annum.

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